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## Light Variations of the Anomalous Central Star of Planetary Nebula Sh 2-71

Z. Mikulášek<sup>1,3</sup>, A. Skopal<sup>2</sup>, M. Zejda<sup>1,3</sup>, O. Pejcha<sup>3</sup>, L. Kohoutek<sup>4</sup>,  
D. Motl<sup>3</sup>, A. A. Vittone<sup>5</sup>, L. Errico<sup>5</sup>

<sup>1</sup>*Institute of Theoretical Physics and Astrophysics, Masaryk University, Kotlářská 2, CZ-611 37 Brno, Czech Republic, mikulas@ics.muni.cz*

<sup>2</sup>*Astronomical Institute of the Slovak Academy of Science, SK-059 60 Tatranská Lomnica, Slovak Republic*

<sup>3</sup>*N. Copernicus Observatory and planetarium, Kraví hora 2, CZ-616 00 Brno, Czech Republic*

<sup>4</sup>*Hamburg Observatory, D-21029 Hamburg, Germany*

<sup>5</sup>*INAF Osservatorio Astronomico di Capodimonte, I-80131 Napoli, Italy*

**Abstract.** We present an analysis of light variations in  $UBV(RI)_C$  of the anomalous object in the center of planetary nebula Sh 2-71. We refined the linear ephemeris of the light maxima to  $JD_{\max} = 2449862.0 + 68.101 (E - 96)$ , but also identified long-term, obviously non-periodic variations. The latter manifest themselves in large O-C shifts, a variable profile of light curves (hereafter LC) and changes in the mean brightness of the object. Our spectroscopic observations suggested the presence of a superdense nebula in the center of Sh 2-71.

### 1. Introduction

The variability of the central object in the planetary nebula Sh 2-71 was discovered by Kohoutek (1979). Jurcsik (1993) revealed a 68.064-day period in the nearly parallel  $UBV(RI)_C$  light variations of the central star. Mikulášek et al. (2005) enlarged photometric data by their  $V(RI)_C$  observations from 1999–2002 and using all  $V$  data improved the period to 68.132 days. They noticed differences between LCs of various colours and a scatter in the (O-C)-diagram.

### 2. Observations

This study presents first results of PCA analysis of light behaviour of the object based on all available photometric data obtained during the time interval of 29 years. We have processed a large set of 4268 observations from three sources:

Author	years	$U$	$B$	$V$	$R_C$	$I_C$	sum
Kohoutek	77–79	81	82	100	-	-	263
Jurcsik	90–93	392	401	403	403	402	2001
Our paper	99–05	-	-	750	794	460	2004
	$N_{\text{tot}}$	473	483	1253	1197	862	<b>4268</b>

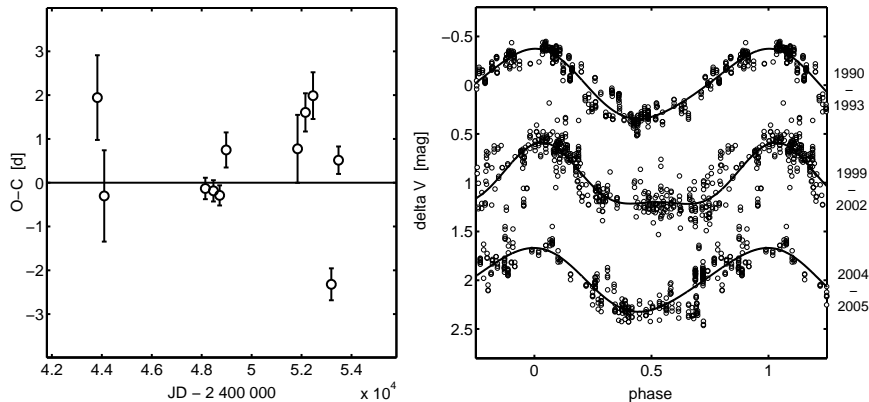


Figure 1. The O-C diagram and the long-term variations in the  $V$ -LC.

1. Partly unpublished  $UBV$  observations made by Kohoutek at Wise Observatory at Mitzpe Ramon, Israel, in 1977–79, at ESO at La Silla, Chile and at the Hamburg-Bergedorf Observatory, Germany, in 1979.
2. Unpublished  $UBV(RI)_C$  observations made by Jurcsik (2003) at Konkoly Observatory in 1990–93.
3. Unpublished  $V(RI)_C$  CCD photometry made by M. Zejda, P. Hájek, O. Pejcha, J. Šafář, P. Sobotka, D. Motl and others at Brno (1999–2005) and Vyškov (2001–2005) Observatories.

### 3. Periodic light variations

Analysis of photometric data confirmed the basic 68-day periodic variation of the object in all passbands. Application of own robust (Mikulášek et al. 2003) PCA code PERISH to all 4268 individual photometric observations allowed us to derive the linear ephemeris for timings of the light maxima as

$$JD_{\max} = (2\,449\,862.02 \pm 0.32) + (68.101 \pm 0.010)(E - 96). \quad (1)$$

The profile of the  $U$ -LC differs from those observed in other passbands.

### 4. Long-term variations

Photometric monitoring of Sh 2-71 during the last 15 years (1990–2005) revealed long-term variations in its light. Residuals resulting from the linear ephemeris (1) suggest a non-periodic shifts of LC as whole (Fig. 1a). Further we selected the  $V$ -LC during three periods (1990–93, 1999–2002, 2004–05) well covered by observations (Fig. 1b). During the 1999–02 period the minimum became flat from the phase 0.3 to 0.75. In addition, a different average  $V$ -magnitudes were measured during 1990-93, 1999-2002 and 2004-05. It was 13.48, 13.59 and 13.50, respectively.

According to the binary model of the core of Sh 2-71 (Cuesta & Phillips, 1993) we interpret the periodic variation in the LC as due to the orbital motion of

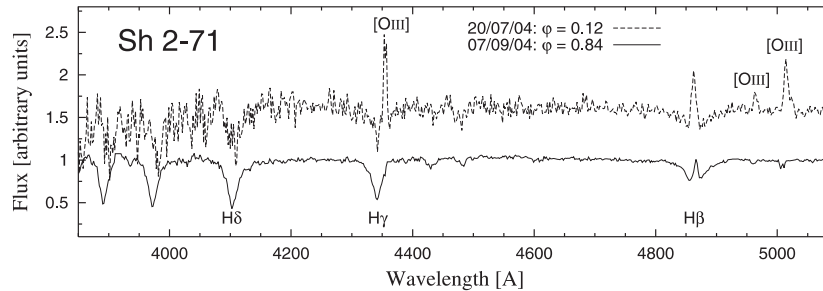


Figure 2. Low-resolution spectra of the core of Sh 2-71.

the binary components. The variability could be caused by different projection of an optically thick inner nebula due to the orbital motion. The long-term changes may be attributed to a variable mass transfer between the components.

Our two low-resolution spectra of the central object of Sh 2-71 carried out at the Loiano Observatory with the BFOSC spectrograph on 20/07/04 (phase 0.12) and 07/09/04 (phase 0.84) support this interpretation. They indicate strong change in the ionization conditions at these phases (Fig. 2). The ratio  $R = (F(4958) + F(5007))/F(4363) = 3.3$  suggests a superdense inner [O III] nebula likewise in symbiotic binaries (Skopal et al. 2001).

## 5. Conclusions

We refined the average linear ephemeris of the periodic variation in all  $UBV(RI)_C$  LCs. Revealed long-term variations manifest themselves in found changes of (i) timing the light maxima as suggested by the O-C residuals, (ii) the profile of the V-LC, which occasionally becomes flat for a large phase interval, and (iii) the variable average brightness of the nucleus.

Our low-resolution spectroscopy revealed apparent differences between the spectra taken in different phases. Fluxes of [O III] nebular lines suggest a very dense inner nebula of Sh 2-71.

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